DATA COLLECTED BY A SURFACE METEOROLOGICAL STATION AT AUBERRY, CALIFORNIA, DURING FALL 2000/WINTER 2001 FOR THE CALIFORNIA REGIONAL PM_{10}/$PM_{2.5}$ AIR QUALITY STUDY

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1. INTRODUCTION

From November 30, 2000, through February 9, 2001, Sonoma Technology, Inc. (STI) operated and processed data from a 10-m surface meteorological tower at the Sierra Nevada Foothills (SNF) site located in Auberry, California for the California Air Resources Board's (ARB) California Regional Particulate Air Quality Study (CRPAQS). This report discusses the operations of these instruments. All the quality-controlled surface meteorological data are in the STI CRPAQS Database.

The description of the site in Auberry, California, and geographic details are given in **Table A-1-1**. **Figure A-1-1** illustrates the location of the SNF site**.**

Table A-1-1. CRPAQS surface meteorological site information

Site Name City, State	Site ID	Latitude (°N)	Longitude (°W)	Elevation (m)	Topographical Setting
Sierra Nevada Foothills Auberry, CA	SNF	36.74	119.25	597	Grassy field between a few houses and the Swiss Dane Factory. Foothills surround the area about one-quarter mile away. Tower located northwest of trailer housing electronics and ozone monitors.

The 10-m surface meteorological tower was configured to measure wind speed and wind direction at 10 m agl. Air temperature, relative humidity, solar radiation, and atmospheric pressure were measured at 2 m agl.

Overall, this project was successful in creating a nearly complete surface meteorological dataset for the measurement period. Data losses were minimal and mostly attributed to software malfunctions.

The data volume is arranged in sections that can be used to decode and interpret the data. The report is organized as follows:

- Section 2: Summary of Operations
- Section 3: Surface Meteorological Data File Structure
- Section 4: Data Processing and Quality Control
- Section 5: Surface Meteorological Instruments
- Section 6: References

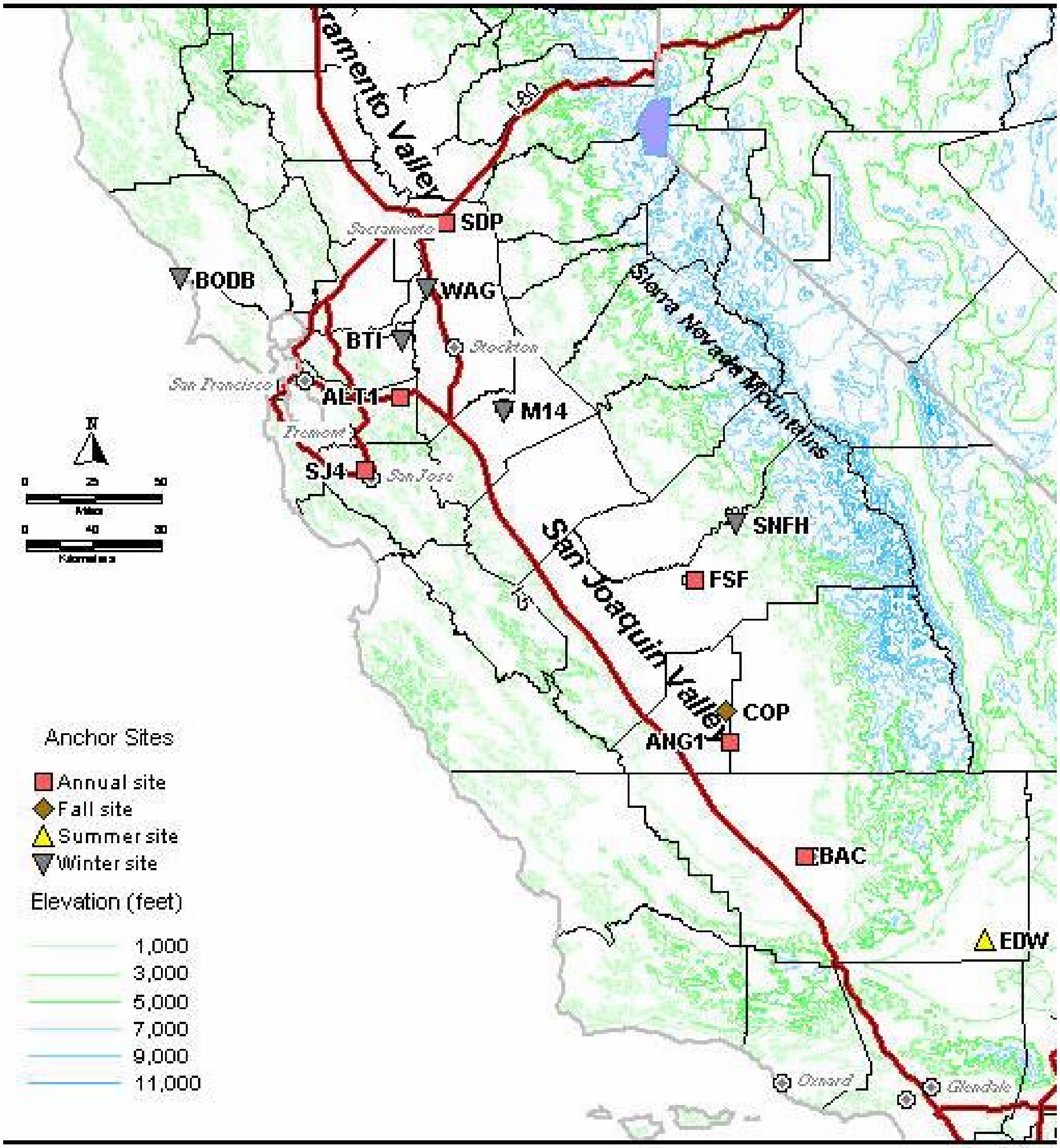

Figure A-1-1. Map of Central California illustrating the CRPAQS anchor sites. The Sierra Nevada Foothills (SNFH) site is represented as a winter site located northeast of Fresno (FSF).

2. SUMMARY OF OPERATIONS

The operations were divided into three phases: setup, routine operations, and data reporting:

- During the setup phase, data from the instruments were downloaded and checked for reasonableness against internal and external data sources.

- Routine operations were conducted daily from November 30, 2000, through February 9, 2001, and consisted of automatic downloading and checking the data. Data were checked for completeness and verified by checking the instrumentation with other sites. If problems were encountered with the data, staff worked to resolve them. Once the data were successfully downloaded, they were automatically uploaded to STI’s website, manually reviewed, and archived. Section 4 describes the daily routine operations and quality control (QC) procedures in depth.

- The data-reporting phase started at the end of the routine operations period. During the data-reporting phase, data were inventoried and missing data were verified with maintenance check lists and operations logs. Data were also manually QC’d to Level 1.0, and data completeness statistics were calculated. The final steps of this phase consisted of transferring the data to the CRPAQS Data Management System Database for delivery and compiling this data report appendix.

2.1 SAMPLING CONFIGURATIONS

The 10-m surface meteorological tower was configured to measure wind speed and wind direction using the RM Young AQ wind speed and wind direction sensor at 10 m agl. Air temperature, dew point temperature, relative humidity, solar radiation, and atmospheric pressure were measured at 2 m agl. Five-minute and 60-minute averages were collected. The sampling configurations for the surface meteorological sensors are shown in **Table A-2-1**.

Table A-2-1. Sampling configurations used for the surface meteorological sensors.

Specification	Surface Meteorology
Averaging period (min)	5 and 60
Reporting interval (min)	5 and 60
Time standard	PST
Time convention	Begin

The completeness of the surface meteorological data has been characterized by reporting the data completeness and data recovery percentages for all the instruments. **Table A-2-2** shows the operational status of the equipment at the site. The data completeness rates were computed from the 5-minute and 60-minute data and were calculated using the following equation:

$$\text{Data Completeness Rate} = ((\text{NumRec})/(\text{NumPos}))*100$$

where:

NumRec = Number of data points received during the reporting period.
NumPos = Number of points possible during the reporting period.

Table A-2-2. Data completeness rates for the SNF site.

Five-Minute Averaged Surface Meteorology (%)	Sixty-Minute Averaged Surface Meteorology (%)
99.8	99.6

Downtimes were usually due to software malfunction. **Table A-2-3** lists the dates and times when major downtimes occurred and the events that affected the data recovery and/or data quality.

Table A-2-3. Major events that affected data recovery and/or data quality.

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Date (Time) MST	Problem	Data Type	Effect on Data
12/01/00 (0959-1209)	Software malfunction	5-min. surface met.	Missing
12/03/00 (1440-1505)	Software malfunction	5-min. surface met.	Missing
12/13/00 (2000)	Software malfunction	5-min. surface met.	Missing
12/13/00 (2009)	Software malfunction	5-min. surface met.	Missing
2/04/01 (1201-1206)	Software malfunction	5-min. surface met.	Missing
12/01/00 (0909-1109)	Software malfunction	60-min. surface met.	Missing
12/03/00 (1410)	Software malfunction	60-min. surface met.	Missing

Table A-2-3. Major events that affected data recovery and/or data quality.

Date (Time) MST	Problem	Data Type	Effect on Data
12/14/00 (1409)	Software malfunction	60-min. surface met.	Missing
2/04/01 (1111)	Software malfunction	60-min. surface met.	Missing

The data completeness represents the overall quantity and quality of the data that were collected. A measure of the quantity of data is reported by the data completeness rate while a measure of the quality of the data is reported by the data recovery rate. The data completeness and data recovery rates were calculated from the data recorded by each of the instruments over the entire data collection period.

The data recovery rates can be used to evaluate the performance of the instruments and are defined as the percentage of valid data points of the number of total data points received (valid or otherwise). **Table A-2-4** shows the data recovery rates for the surface meteorological station. The data recovery rates were calculated using the following equation:

$$\text{Data recovery rate} = [(\text{NumValPts}) / (\text{NumRecPts})] * 100$$

where:

NumValPts = The number of valid data points passing the Level 1.0 data validation.

NumRecPts = The total number of data points received.

Table A-2-4. Summary of surface data recovery rates.

Bin Range (m agl)	Atm. Pressure (%)	Solar Radiation (%)	Ambient Temp. (%)	Rel. Humidity (%)	Resultant Wind (%)
Surface (5-min.)	100.0	100.0	100.0	99.9	100.0
Surface (60-min.)	100.0	100.0	100.0	100.0	100.0

2.3 DATA PROBLEMS

The wind sensor cross-arm was aligned to magnetic north instead of true north. To determine true north, a solar siting was completed to establish the actual declination of 14.55°. An offset was applied to the wind direction data to account for the alignment with magnetic north. At the start-up of data collection, we determined that the data collection system was reporting spurious data due to the manner in which the data management system collected the data from the data logger. While a solution was not found, the spurious data were removed as part of the data validation process.

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3. SURFACE METEOROLOGICAL DATA FILE STRUCTURE

The surface data file structure is discussed in the body of this report. A line-by-line breakdown of the surface data variables is shown in **Tables A-3-1 and A-3-2.** The first five fields of each record contain data identifying the record (i.e., date, time). The remaining fields for each record contain the meteorological parameters measured (i.e., wind direction, wind speed, etc.) and a QC code field for each parameter.

Table A-3-1. Format and units of 5-minute averaged surface meteorological data file records.

Field Name	Contents	Units
Val Lvl	Data validation level	-
Sta Cod	Site ID	-
Jul Day	Julian day	ddd
Date	Date	yymmdd
Time	Time	hhmmss
M5_AmbT	Temperature—5-minute average	°C
QC	QC flag for M5_ambT	-
M5_AtmP	Atmospheric pressure—5-minute average	mb
QC	QC flag for M5_atmP	-
M5_DP	Dew point temperature—5-minute average	°C
QC	QC flag forM5_DP	-
M5_MWS	Mean Wind speed—5-minute average	m/s
QC	QC flag for M5_MWS	-
M5_RWD	Resultant wind direction—5-minute average	degrees (true)
QC	QC Flag for M5_RWD	-
M5_RWDSD	Standard deviation of wind direction—5-minute average	degrees (true)
QC	QC flag for M5_RWDSD	-
M5_RWS	Resultant wind speed—5- minute average	m/s
QC	QC Flag for M5_RWS	-
M5_RH	Relative humidity—5- minute average	%
QC	QC flag for M5_RH	-
M5_Srad	Total incoming solar radiation—5- minute average	W/m^2
QC	QC flag for M5_Srad	-

Table A-3-2.   Format and units of 60-minute averaged surface meteorological data file records.

Field Name	Contents	Units
Val Lvl	Data validation level	-
Sta Cod	Site ID	-
Jul Day	Julian day	ddd
Date	Date	yymmdd
Time	Time	hhmmss
M_AmbT	Temperature—60-minute average	°C
QC	QC flag for M_AmbT	-
M_AtmP	Atmospheric pressure—60-minute average	mb
QC	QC flag for M_AtmP	-
M_DP	Dew point temperature—60-minute average	°C
QC	QC flag for M_DP	-
M_MWS	Mean Wind speed—60-minute average	m/s
QC	QC flag for M_MWS	-
M_RWD	Resultant wind direction—60-minute average	degrees (true)
QC	QC Flag for M_RWD	-
M_RWDSD	Standard deviation of wind direction—60-minute average	degrees (true)
QC	QC flag for M_RWDSD	-
M_RWS	Resultant wind speed—60-minute average	m/s
QC	QC Flag for M_RWS	-
M_RH	Relative humidity—60-minute average	%
QC	QC flag for M_RH	-
M_Srad	Total incoming solar radiation—60-minute average	W/m^2
QC	QC flag for M_Srad	-

4. DATA PROCESSING AND QUALITY CONTROL

This section describes the steps that were followed to acquire, process, and perform QC screening of the surface meteorological data collected during the sampling period.

Every five minutes, data from the data logger was automatically sent to the STI Data Acquisition System (DAS) on the local site computer. At midnight every night, the surface meteorological data were then sent to the STI data management center in Petaluma for processing, validation, and storage. Each morning, staff reviewed the data to verify that all data had been received. If the data were not received, staff made phone calls to the site to determine the cause of the problem. Sometimes the site operator was summoned to the site to perform repairs that could not be completed remotely. Ultimately, the data were delivered to the California ARB CRPAQS database.

The data validation process involved identifying inconsistent observations (outliers) and assigning QC codes to each data point to indicate its validity. There were three stages, or levels, in the data validation process:

- <u>Level 0 validation</u>. Raw, non-QC'd data obtained directly from the data loggers in the field.
- <u>Level 1A validation</u>. Data passed several validation tests guided by the measurement expert prior to data submission:
    - flagging/removal of data when instruments did not function within procedural tolerances;
    - flagging when significant deviations from measurement assumptions occurred;
    - replacing data from a backup DAS; adjusting values for interference biases;
    -
- <u>Level 1B validation</u>. Data file naming conventions, formats, site codes, variable names, reporting units, validation flags, and missing value codes were consistent with project conventions. Also, values were identified that
    - were outside a specified minimum or maximum value;
    - changed by more than a specified amount from one sample to the next;did not change over a specified period.

1. The Level 0 data were downloaded from the site database.
2. Manual review of the data was performed. The reviewers carefully examined plots of the data, looked for outliers, and evaluated the reasonableness of the data. The reviewers verified the results of the automated QC screening, either accepting the results or redefining "suspect" data as "valid" or "invalid", as appropriate.

The following QC codes were used:

0 = Valid
1 = Valid, no vertical correction
2 = Valid, calibration applied
8 = Invalid with a data value of:
-940 = failed auto QC
-950 = unable to create consensus average
-960 = radial velocities too high/low
-980 = invalidated by reviewer
9 = Missing with a data value of –999

Note: We recommend using only data with a QC code ≤ 2.

3. Reviewers used internal and external sources of data to help them determine the validity of the observations. **Table A-4-1** lists internal data sources that were commonly used and gives a brief explanation of their use. Internal data sources included other parameters that were measured by the same instrument, collocated data sources, and other internally generated data (e.g., instrument performance logs and site operator logs). For example, when checking temperature data, staff often relied on nearby sites at similar elevations to determine reasonableness.

Table A-4-1. Internal data sources used during data validation.

Internal Data Sources	Usage
Results of instrument calibrations: wind sensor starting thresholds and linearity, comparisons of temperature, RH, and pressure data to collocated transfer standards, etc.	Check for accuracy and precision of sensors.
Site operator logs	Check for instrument problems and corrective actions. Check on weather conditions and instrument condition during the operators’ visits to the sites.

Table A-4-2 lists external data sources and gives a brief explanation of their use. Examples of external data include National Weather Service (NWS) surface weather charts and satellite images. NWS surface analyses compared to measured surface winds to perform reasonableness checks are an example of external data use.

Table 4-2. External data sources used during data validation.

External Data Sources	Explanation of Usage
NWS surface meteorological charts	Track synoptic scale weather features (i.e., frontal positions, thunderstorms) that may affect instrument performance or data quality.
Satellite images	Track synoptic-scale weather features (i.e., frontal positions, thunderstorms) that may affect instrument performance or data quality.
Surface data from other sites	Perform checks of temporal and spatial consistency.
NWS surface data	Check for temporal and spatial consistency in the wind speed, wind direction, temperature, pressure, moisture, and solar radiation data.
Audit report data	Verify instrument performance.

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5. SURFACE METEOROLOGICAL INSTRUMENT DESCRIPTIONS AND SPECIFICATIONS

The surface meteorological sensors that were used and their specifications from the manufacturer's product literature are listed in **Table A-5-1**.

Table A-5-1. SNF surface meteorological equipment specifications.

Measured Parameter	Sensor Manufacturer	Sensor Model	Sensor Serial Number	Sensor Specifications	
Wind velocity	RM Young	AQ/PSD Wind Monitor	22211 Sensor 56702 Prop	Accuracy: Range	±0.07 m/s 0-60 m/s
Wind direction	RM Young	AQ/PSD Wind Monitor	22211 Sensor 56702 Prop	Accuracy: Range:	±2° 0-360°
Temperature	Climatronics Corp.[a]	TS-10	1065	Accuracy: Range:	±0.15°C -30.0° to 50°C
Pressure	Setra	Setra 800 mb	420	Accuracy (55°-85°F): Range:	±1.5 mb 800-1100 mb
Relative humidity	Vaisala	HMP45C	V0410019	Accuracy: Range:	±4% RH 0-100% RH
Solar radiation	Climatronics Corp.	Licor 200	PY12159	Accuracy: Range:	±5% 0 – 1400 W/m^2

[a] The temperature sensor was mounted in a Climatronics Corp. motor-aspirated solar radiation shield, model TS-10, which draws air past the sensors at a rate of 3 m/s.

The surface meteorological data acquisition systems consisted of two components: a Campbell Scientific, Inc. model CR-10 data logger and the STI Data Acquisition System. The data logger sampled the meteorological sensor outputs once every 2 seconds, converted the outputs to engineering units, and produced 5-minute and 60-minute averages of each parameter. Standard deviations were also computed for wind speed and direction variables. The standard deviations of the wind direction ($\sigma\theta$) data were computed following U.S. Environmental Protection Agency recommendations. The data logger was linked to the computer via an RS-232 serial interface. The data logger used this link to automatically send the meteorological data from the data logger to the STI Data Acquisition System.

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6. REFERENCES

California Air Resources Board (2001) CRPAQS Homepage. http://www.arb.ca.gov/airways/crpaqs/default.htm, last accessed September 2001.